SYSTEM STORAGE OPTIMIZATION REPORT

MIAMI-DADE WATER AND SEWER DEPARTMENT

PROJECT SUPPORT SECTION

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Table of Contents

List of Figures and Tables

Chapter 1

Background and Overview

1.1 Introduction

The Miami-Dade Water and Sewer Department (MDWASD) provides wastewater service for approximately 2,000,000 customers in Miami-Dade County, Florida. The topography of the county is essentially flat, with elevations generally varying between 12 and 6 feet above mean sea level. As a result, wastewater is most economically conveyed with numerous pumping stations with service areas averaging approximately one quarter square mile in size. The MDWASD system is comprised of over 950 pumping stations. Beneath the ground surface lays the Biscayne Aquifer, the primary drinking water supply for the county. This aquifer has a very high tranmissivity, with groundwater levels typically varying from 4 to 9-10 feet below grade. Due to these conditions, the gravity sewers in the MDWASD system are submerged in groundwater to a large degree, conditions which lead to groundwater infiltration.

As part of a Consent Decree with the United States Environmental Protection Agency (USEPA), MDWASD has undertaken a massive infiltration/inflow (I/I) program to reduce quantities of water being admitted to the sewers. An aggressive I/I program is underway to identify and expedite sewer repairs in the collection system. The I/I is a critical element of the overall WASD expansion program. If the I/I is not significantly reduced, the additional groundwater reaching the treatment plants increases the need for greater transmission and treatment capacity.

The Figure 1 below shows a typical collection system with wastewater being transmitted to the pump station. The figure also shows infiltration and inflows flows into the collection system due to defects in the sewers. During a rain event, inflow occurs and the infiltration rate increases as the groundwater table increases.

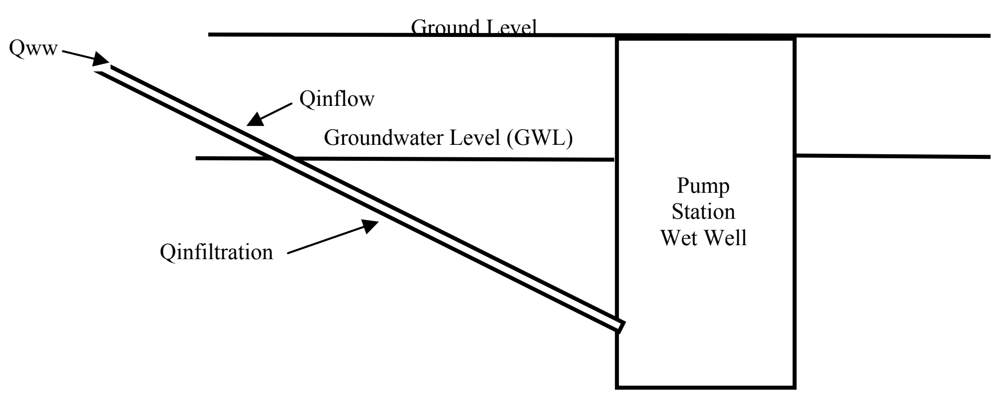


Figure 1. Typical Pump Station Collection System Flows.

If the sum of the flows to the pump station ($Q_{ww}+Q_{infiltration}+Q_{inflow}$) exceeds the PS capacity (Q_{ps}), the system will surcharge. As the system surcharges, the PS capacity increases due two the additional system head on the suction side of the pumps and the infiltration rate decreases as the groundwater differential head decreases. The collection system surcharge level will reach an equilibrium and stabilize when

$$Q_{ps} = Q_{ww} + Q_{infiltration} + Q_{inflow}$$

If the system surcharges close to the groundwater level the infiltration becomes negligible, and the above equation becomes

$$Q_{ps} > Q_{ww} + Q_{inflow}$$

Therefore, when a collection system surcharges to the groundwater level, no system overflows can take place if the PS capacity exceeds the wastewater plus the inflows flows.

After a storm event, the inflow goes to zero, and the surcharged system equation becomes

$$Q_{ps} > Q_{ww}$$

This implies that, after a storm event, the PS capacity must only exceed the wastewater flow in order to prevent system overflows.

A typical PS will have two pumping units installed with one unit operating a maximum of 10 hours per day according to the consent decree requirements. The lead pump will operate at preset wet well levels. If surcharge equilibrium can not be maintained because the system flows continue to exceed the pump capacity, the second pump will start at a given fixed level under the groundwater level, providing a safety factor to prevent overflows by helping to pump the system down to a lower surcharge level.

This procedure will greatly reduce, and possibly eliminate system exfiltration and/or overflow conditions during extreme storm events. It should satisfy the requirements of the consent decree during a two year storm. If a more severe storm occurs, overflows will be greatly reduced since the transmission system would not be immediately overloaded and system storage would alleviate the impact of the initial inflow flows.

The groundwater head is the driving force on infiltration leaks. If the groundwater head on a given leak increased, the amount of infiltration is increased. Conversely, if the groundwater head is decreased, the amount of system infiltration will decrease. If a gravity collection system is surcharged by allowing the wastewater to back-up into the collection system, it will effectively reduce the groundwater head on the surcharged portion of the sewer.

The relationship between the pump station operating level and the system infiltration rate can be illustrated in the following way. If it is assumed that the gravity systems are pumped down below the invert, the groundwater head on each sewer leak would equal the distance the leaking sewer pipe is below the groundwater level. According to data collected from our system, the average gravity sewer invert at the wet well is about 8 ft below the GWL. In this case, the maximum driving force at the invert would be approximately eight feet of water and the average system pressure would be 8/2= 4 feet. Let us consider that night flow measurements during average groundwater conditions indicate a system infiltration rate of X Mgd when the system is pumped down. Under this scenario, these X Mgd of infiltration would have an average driving force of 4 feet of water.

If the pump station operates at four feet directly above the sewer invert, the average system operating head is 3 feet. From system hydraulics we know that

$$Q_1/Q_2 = (h_1/h_2)\text{^}1/2$$

Considering that

$$Q_1 = X \text{ Mgd} \ ; \ h_1 = 4.0 \text{ ft} \ ; \ h_2 = 3.0 \text{ ft}$$

Then

$$Q_2 = X^*(1.73)/2 = 0.865X \text{ Mgd}$$

If the pump station operates with the upper level of the operating range two feet below the groundwater level then the infiltration rate will be

$$Q_{2'} = X*(1.41)/2 = 0.707X \text{ Mgd.}$$

Then

$$Q_{2'} / Q_2 = 0.707/0.865 = 0.81$$

Therefore, there is about 20% reduction in the infiltration rate when the average system operating level is changed one foot up. These results can give us a general idea of the relationship between the pump station operating level of the pump and the amount of infiltration entering the sewer system.

In order to further reduce the quantities of these flows, including wet weather flows due to gravity sewer leaks above the ground water table, and to obtain the related benefits as described below, MDWASD is undertaking an evaluation of the incorporation of a groundwater level sensor into the pump station controls. This sensor was installed tied to the pump station controls so that pump start-stop elevations will rise and fall with groundwater fluctuations.

The benefits which have been derived from this are as follows:

1. Reduced infiltration by reducing the elevation difference between groundwater and wastewater within the gravity mains. This has reduced the hydraulic gradient driving groundwater into gravity lines.
2. Reduced pump station run times which could substantially affect MDWASD cost for pumping station upgrades to meet the 10 hour adequacy criteria of the First Partial Consent decree with the EPA.
3. Reduction in cost for electric power for pumping.
4. Reduction in the number of pump starts, reducing wear on electrical equipment.

Disadvantages are as follows:

1. Regulatory agency approval is required.
2. A reduction in system storage, reducing safety factors in case of a malfunction or emergency.
3. Increased possibility of a main line or lateral blockages.
4. Increased wet well maintenance.
5. Increased complexity in controls.

Typically, pump control settings are located in such a way to keep wastewater levels below the invert of the incoming gravity sewer. By increasing the elevations of the settings, wastewater backs up into the sewers, decreasing this driving head. With the installation of a monitor well at pump station sites, groundwater can be continuously monitored and control settings continuously adjusted so that a constant distance between the pump "start" elevation and the groundwater elevation can be maintained. This allows for optimizing the infiltration reduction by having the average level in gravity lines as high as possible, while minimizing the possibility of wastewater levels exceeding groundwater elevation, under which conditions exfiltration would result.

1.2 Pump Controls and Monitoring

Controls will be installed in the Supervisory Control and Data Acquisition (SCADA) systems located at the pumping stations. As described in the specifications, computations to determine the effectiveness of the controls have been incorporated into the program. The primary features of the controls and monitoring are as follows:

1. Standard controls, under which pumps are started and stopped, based on fixed levels will be included for purposes of comparison.

2. In order to implement control based on groundwater, the operator will input the three variables described in Table 1, below. When control using groundwater is in effect, the program will periodically update control elevations based on groundwater.

Parameter	Description
d1	Vertical distance from groundwater elevation (variable from level sensor) to lag pump start elevation.
d2	Vertical distance from lag pump start elevation to lead pump start elevation.
d3	Vertical distance from lead pump start elevation to all pump stop elevation.

Table1. Description of Control Parameters

3. As described above, one of the possible disadvantages of this control is the possibility of the clogging of lines due to grease buildups. Features have been included in the controls to regularly pump down the pump station basins in an attempt to minimize such occurrences. Capability to have regular pumpdown cycles based alternatively on a given number of pump cycles and by time will be provided.

4. A feature has been incorporated into the controls to automatically alternate between control with groundwater and standard control in order to quantify the benefit of the proposed modifications.

5. An algorithm has been included in the SCADA program to compute both pumped flow and flow into the pump stations. This algorithm uses pump curves and will be based on a mass balance in the wet well, with calculations being performed over a uniform time step.

Fig. 2. SSOP pump station 573. Center: SCADA RTU panel.
Bottom left corner: Groundwater level monitoring well.

6. Provisions for totalizing flows have been included in the program.

Table 2 below shows the pump station design data.

Pumping Station	155	183	196
No. of Pumps	2	2	2
Horsepower, each	50	40	20

Table 2. Pilot Pumping Station Design and Operating Data (Phase I Stations)

1.3 Determination of Control Parameters

Since the intended operation is based on the measurement of groundwater at the pumping station, it is important, in the setting of the control elevations that the losses in the gravity system at peak flows do not result in levels of wastewater in the system exceeding the groundwater at the extremities of the basin. In order to analyze for this, analyses were performed with XP-SWMM hydraulics software. Computer modeling was based on an estimated diurnal wet weather hydrograph to each of the stations for a two-year storm. Flows were divided evenly among all of the manholes located in each of the station basins.

Based on the computer modeling results, Table 3 provides a summary of the control parameters d1, d2, and d3 to be used for the pilot program. Note that a future refinement of the controls will be to vary these parameters based on flow, reducing them on low (dry weather) flow conditions so that pump station control elevations can be higher while maintaining the same wastewater surface elevations at the basin extremities. Increasing wastewater levels in the basins during dry weather conditions with this control refinement will further reduce groundwater infiltration.

Pumping Station	155	183	196
d1	2.5	8.5	6
d2	1	1	1
d3	2.33	5.25	1.5

Table 3. Pilot Station Control Parameters

Fig 3. SSOP pump station 183. Center top: SCADA RTU panel.
Bottom: Groundwater level monitoring well.

Chapter 2

Methodology and Test Procedures

2.1 Test Procedures

The test procedure was basically broken into two steps as follows:

1. Initial Quantification of Benefits

   The first step was a quantification of the benefits of the proposed modifications. In order to accomplish this, the feature included in the controls program will be to switch automatically between the two modes of control, standard and that using groundwater, on a continuous basis, every other day, for three to four weeks. For periods with relatively constant groundwater, the following parameters were compared for the periods

   Pump Run Time
   Total pumped flow (from SCADA computation)
   Total pump station influent flow (from SCADA computation)
   Power consumption
   No. of Starts

   Groundwater measurements were checked since fluctuations will invalidate comparisons of these variables. During this period, pump station maintenance staff visited the site twice daily, monitoring for proper operation. Staff noted any additional odors which could result from the controls using groundwater.
   Four (4) battery powered level sensors were placed in the collection system during this period to confirm gravity collection system head loss calculations.

2. Long Term (approximately one year) Pilot

   After the initial phase, a one-year pilot program was undertaken to determine the following:

   -Optimum flushing cycles to reduce any clogging in gravity lines due to surcharging.
   -Adjust and fine tune controls.
   -Correct any unforeseen operational problems.

   In order to track long term pressure increases in the vicinity of the pilot stations, monthly average daily operating times for several pumping stations in the vicinity of the pilot stations were recorded and compared to those for the pilot stations.

3. Wet Weather Analysis

   In order to determine the effect of the controls using groundwater during wet weather, the pump station control mode was switched back and forth between the standard control mode and groundwater. As it was anticipated, during the sustained wet weather events, a clear indication of flow reductions was obtained. These results show that this flow reduction is the key benefit obtained with the use of the implemented controls.

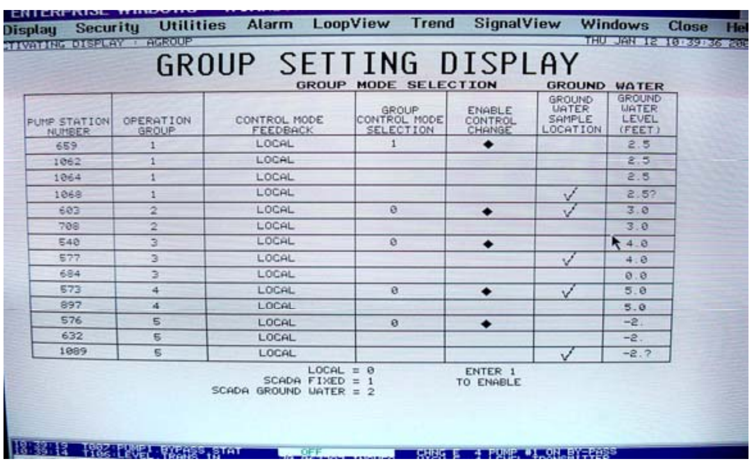
2.2 Current Status SCADA Program Displays

Three pump stations: 155, 183 and 196 were selected within Phase I of the Pilot Project frame, based on SCADA availability, operating hours, and proximity to each other (to facilitate additional surveillance during testing) for the implementation of the program. Basic information about these three stations includes basin schematics, pump station data, and historical groundwater elevations from USGS groundwater monitoring wells in the vicinity of pump stations. These three stations are a part of the group of pump stations selected to continue with the System Optimization Program that includes also the following additional Phase II pump stations: 540, 564, 573, 576, 577, 603, 632, 659, 684, 708, 897, 1062, 1064, 1068, and 1089.

The installation of 5 groundwater monitoring well sample locations is in process of completion for the collection of data. These sample locations will monitor the above mentioned additional pump stations by groups and are located in the following way: one at PS 1068 and including PS 659, 1062 and 1064; one at PS 603 and including PS 708; one at PS 577 and including PS 684; one at PS 573 and including PS 897, and one at PS 1089 and including PS 576 and 632.

Complementary SCADA display additions and modifications have been achieved in the past year, related not only to the three initial pump stations (155, 183, and 196) but also to the additional 15 stations that have been considered for the continuation and expansion of the program. These new and updated displays include, among others:

- **AGROUP:** Group Setting Display (Fig. 4 below)- This screen identifies the operations groups, the control mode feedback, a group control selection column, enable control change column, and ground water level values,



Display Security Utilities Alarm LoopView Trend SignalView Windows Close

GROUP SETTING DISPLAY

			GROUP MODE SELECTION		GROUND WATER	
PUMP STATION NUMBER	OPERATION GROUP	CONTROL MODE FEEDBACK	GROUP CONTROL MODE SELECTION	ENABLE CONTROL CHANGE	GROUND WATER SAMPLE LOCATION	GROUND WATER LEVEL (FEET)
659	1	LOCAL	1	◆		2.5
1062	1	LOCAL				2.5
1064	1	LOCAL				2.5
1068	1	LOCAL			✓	2.5?
603	2	LOCAL	0	◆	✓	3.0
708	2	LOCAL				3.0
540	3	LOCAL	0	◆		4.0
577	3	LOCAL			✓	4.0
684	3	LOCAL				0.0
573	4	LOCAL	0	◆	✓	5.0
897	4	LOCAL				5.0
576	5	LOCAL	0	◆		-2.
632	5	LOCAL				-2.
1089	5	LOCAL			✓	-2.?

LOCAL = 0
SCADA FIXED = 1
SCADA GROUND WATER = 2

ENTER 1
TO ENABLE

Fig. 4. SCADA monitor display. General settings screen AGROUP for groundwater monitoring well operation groups as well as current GW elevations in each group.

- **ALIFTSAT:** Lift Station Status Display (Fig. 5 below)- This screen identifies the communications and wet well level status, wet well level and pressure (PT) values, flushing mode in operation, and pump status and control.

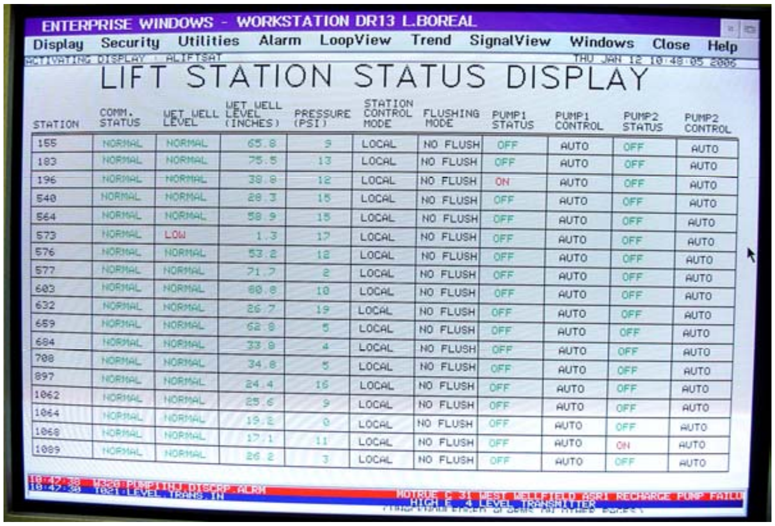


Fig. 5. SCADA monitor display. ALIFTSAT screen on the general status of the selected group of pump stations

- **ALIFTSET**: SCADA Lift Station Control Setup (Fig. 6)- This screen gives the operator the possibility to setup the different options for the start of lead and lag pumps, as well as pump off levels by entering Mean Sea Level Values in feet.

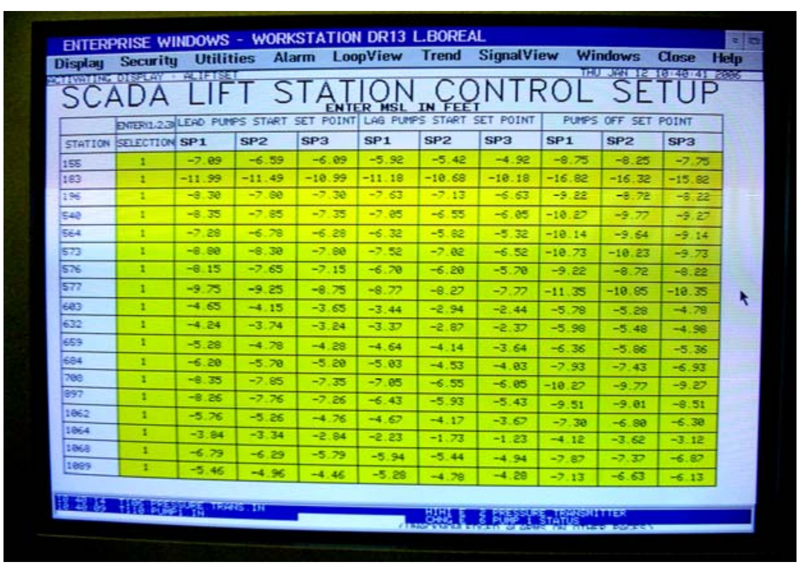


Fig. 6. SCADA monitor display showing ALIFTSET screen for all setting values of lead, lag and all pumps OFF regimes

- **AS(**PS No**.)CTL**: For each of the above listed stations there is an individual pump control setup screen named (Fig. 7 below). This screen displays the control of the lead and lag pump starting points, flushing regimes, pump control modes, and alarms.

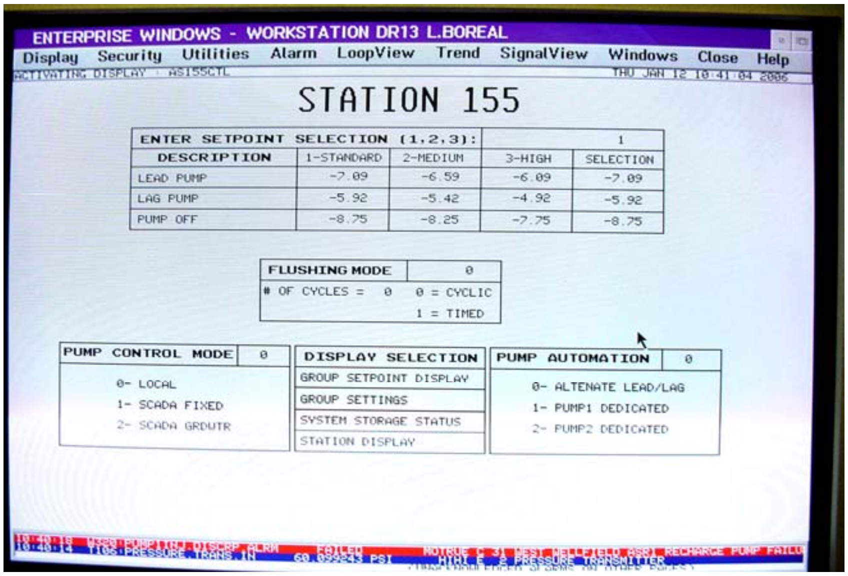


Fig. 7. SCADA monitor. AS155CTL screen for PS 155. Similar screens are already active for the rest of the selected pump stations.

- **ASTN(**PS No**.):** Pump station display (Fig. 8 below) introduces new features as the Station Pump Control and Flushing Mode Control Status, and Wet Well Level values measured in MSL feet.
-

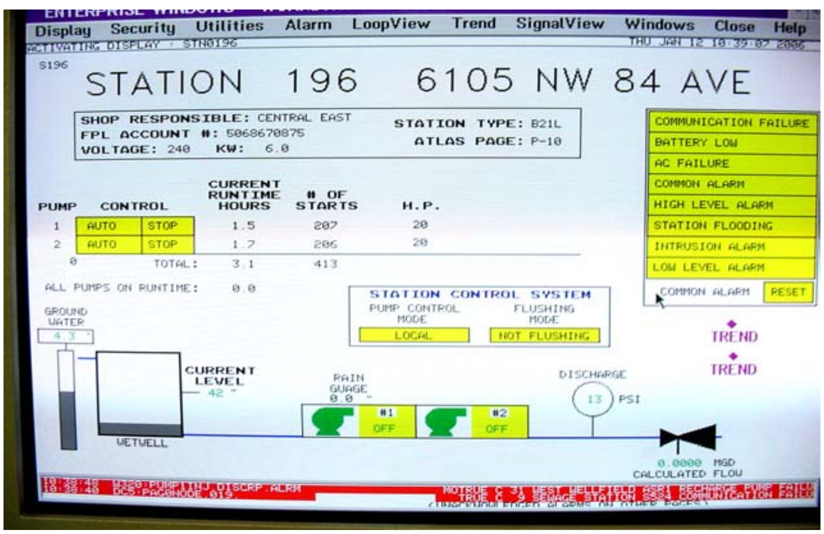


Fig. 8. SCADA monitor display. Screen STN0196 for Pump Station 196. Similar screens are already active for the rest of the pump stations selected in this Program

Graphical display trends for the main parameter signals, like wet well levels, influent flows with pumps on and off, total influent flows, groundwater levels, and power consumption are already implemented for stations 155, 183 and 196, and in process of implementation for the rest of the pump stations listed above.

Monitoring of all these parameters using SCADA displays should be one of the advantages of this system provided that the signals displayed in the different screens have a minimum degree of accuracy and reliability, and reflect the real variations of the monitored physical quantities. This monitoring system should have sufficient sensitivity to model the real situation of the sewer system, not only during normal or standard conditions, but also when the system is surcharged, either due to preset operator actions or to extreme conditions caused by rain or storm events, particularly during the wet weather seasons.

Fig. 9. SSOP Pump Station 196. Center top: SCADA RTU. panel.
Bottom: Groundwater level monitoring well.

2.3 Flow Computation in System Optimization

The behavior of the water level fluctuations inside the wet well is a physical process that takes place in a rather smooth fashion. Except for some flash overloads due to some transient event, time variations of the wet well level can be of the order of several tens of seconds as the reviewed experimental data shows, under loading regimes and specific short intervals of time (that could be up to several minutes), the flow rate entering the wet well can be considered linearly dependent on time.

That is not the case when we consider readings of the pressure transmitter (PT). As we can see from Fig 10 below, which is a typical PT time pattern for any OFF cycle for the same time interval considered, the variations in the pressure values can go from more than 26 psi to as low as 2 psi. These variations have not taken place in a smooth and regular fashion, but rather in a erratic and random way, with oscillations as large as 22 psi. In terms of feet of head these variations can represent values of about 50 feet, and represent a great fraction of the values measured by the PT transducer system.

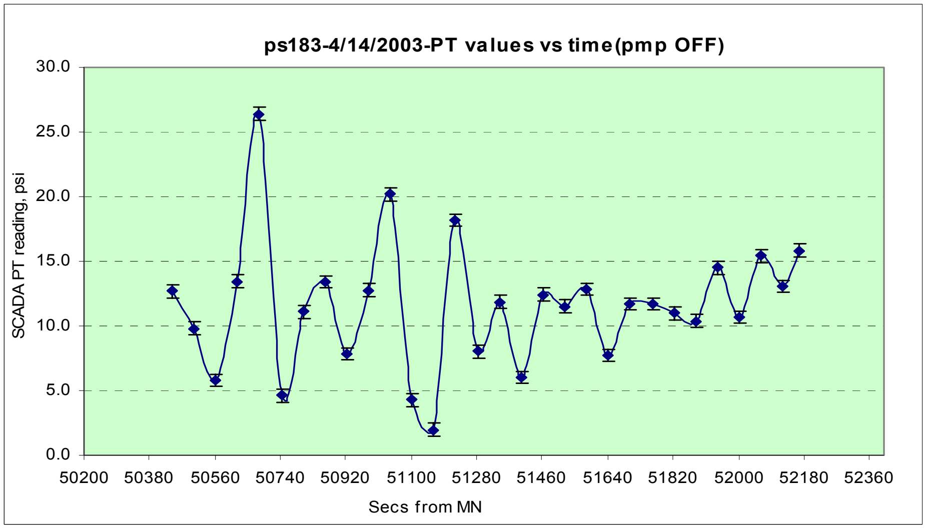


Fig.10. Time variations of pressure transmitter. Recording time intervals are 60 sec. long. Pump is in the OFF semi-cycle. Note the erratic, random behavior of pressure values.

2.4 Factual Considerations and Basic Assumptions

As we can see from experimental data, this constant random behavior of PT values along time is present whether or not pumps are ON or OFF, which characterizes a situation in which the downstream pressure conditions, that is, toward the forcemain system, are influencing constantly the way PT sensors transmit data to SCADA systems. The origin of these random behavior is a consequence of the superimposed effects of all the pumping facilities struggling for a place through the given force main system, and could be considered as a “random noise” that should be processed in order to extract the useful signals for the processing of the data.

On the other hand, transition and boundary conditions in the acquisition of raw data are the cause of transient distortions along the information streams on the program algorithms that should be eliminated by using some kind of pre-processing of the raw data before their use by the SCADA computing program. Pump start and stop events introduce random false pressure transducer values in the computation algorithms which compromise the accuracy of computations.

2.5 Random influence of the forcemain conditions on pump station parameters.

The effect of variations of pump station wet well levels on the pump output flows were preliminarily investigated for two specific pump stations included in the Pilot Program: 155 and 183. Variations of WW levels taken from SCADA records on 4/14/2003 during pump OFF intervals (60 s) and pump ON intervals (10 s) were considered for this research.. Measurement errors in time, WW level and PT readings were estimated as +/-1 s, , +/-1 in , and +/-0.5 psi, respectively. Each pair of pumps at the pump station was considered identical from the point of view of curve performance considerations.

A preliminary investigation of the behavior of PT readings while the pumps were OFF revealed apparent instabilities of the static head over time. These instabilities which are present all the time, can be of the order of several psi along periods of 1 minute and are totally of a random nature. This "noisy" pattern remains constant, despite the time interval selected. The mean value for the PT readings was 15.1 psi with a mean standard deviation (for the series of intervals considered) of 2.4.

This random behavior of the PT readings is not supposed to be associated with any malfunction of the measuring devices, but due to real fluctuations of the pressure on the force main side of the system, caused by the interaction of the group of pumps starting and stopping over the common force main pipes. These fluctuations will be present as well during the ON semi-cycle of the pump, and because the influence of the particular pump station is just a small fraction of the entire system, these fluctuations will be superimposed to the actual measurements of the PT during ON semi-cycles. Due to the random behavior of these fluctuations, the value of the PT readings will be randomly affected as well, and the uncertainty in the measurement of PT values when the pump is ON will be determined by the uncertainty of this "background noise". Consequently, any calculated parameter based on these readings should be correspondingly affected as well.

2.6 Stabilization of pump output flows with respect to wet well working water levels

These experimental results show that, while the WW levels decrease uniformly with time, the PT values behave following random patterns, due to the influence of the rest of the basin on the force main side. The behavior of the PT values is modulated by the combined and prevailing behavior of the rest of the pumping system. As can be seen from the statistical analysis of results, there is no evidence of correlation between the behavior of the WW levels and the PT readings, and if there is, it is masked by the random behavior of the rest of the system. On the other hand, the linear relationship between WW level and time reinforces the idea that the pumping rate change, under these conditions, is so small its change can not be determined from data in wet well water levels for both WW level regimes: below invert and surcharged.

Using adequate preprocessing and filtering of the raw data, the information can be used in the calculation of the corresponding program mathematical expressions to obtain reliable sets of values that generate more real-time graphic displays and accurate flow computations. In this way the computation of corresponding values for the modified head pressures and pump K loss factors will reflect statistical quantities that maintain stable values with which we can work within a given margin of reliability.

Chapter 3

Results, Conclusions and Recommendations

3.1 Determination of the Pump Station K Loss Factor

The characterization of the values of the loss factor K is determined by the nature of the data from which it is calculated. The loss factor K is calculated from SCADA wet well levels and PT readings, the last one being the signal with more statistical uncertainty. Therefore, the main source of errors in the determination of the modified head H_m and of K, will be from the PT readings, and not from the wet well readings.

Consequently, the uniqueness of the values determined for K will be affected by these statistical errors that can not be avoided in the analysis of the results. A preliminary statistical estimation of the error in the determination of K yields about +/- 0.00001 for this particular pump station (#155).

As a consequence of this, H_m has a characteristic curve that will reflect the range of error for the different computed values of the curve. Expected values for H_m, given a certain value of **Q**, will be found within the error interval given along the graph, as it is shown in Figure 11 below. We can talk, therefore, about a “modified head band” instead.

A series of 30 pump cycles taken at random during one normal operation day were considered for the statistical determination of the modified head values, pump flows and modified curve. Mean values for the influent flow and modified head were obtained following a procedure similar to that used by SCADA programming software. The determination of the pump flows during each ON cycle were based on the reasonable (based on experimental data) supposition that the influent flow rate does not vary dramatically while the pumping is working. Values of manufacturer’s head values (H_{pc}), modified head values H_m, and flows Q were used to calculate the loss factor K for this pump station, and this value was used to compute the modified curve. Corresponding values for the standard deviation and intervals of confidence were determined. A set of H_m values was calculated to obtain the modified curve by solving the second degree equation involving K, H_m and Q for a range of values of the flow similar to that of the original pump curve. These results are summarized in figure 11 below.

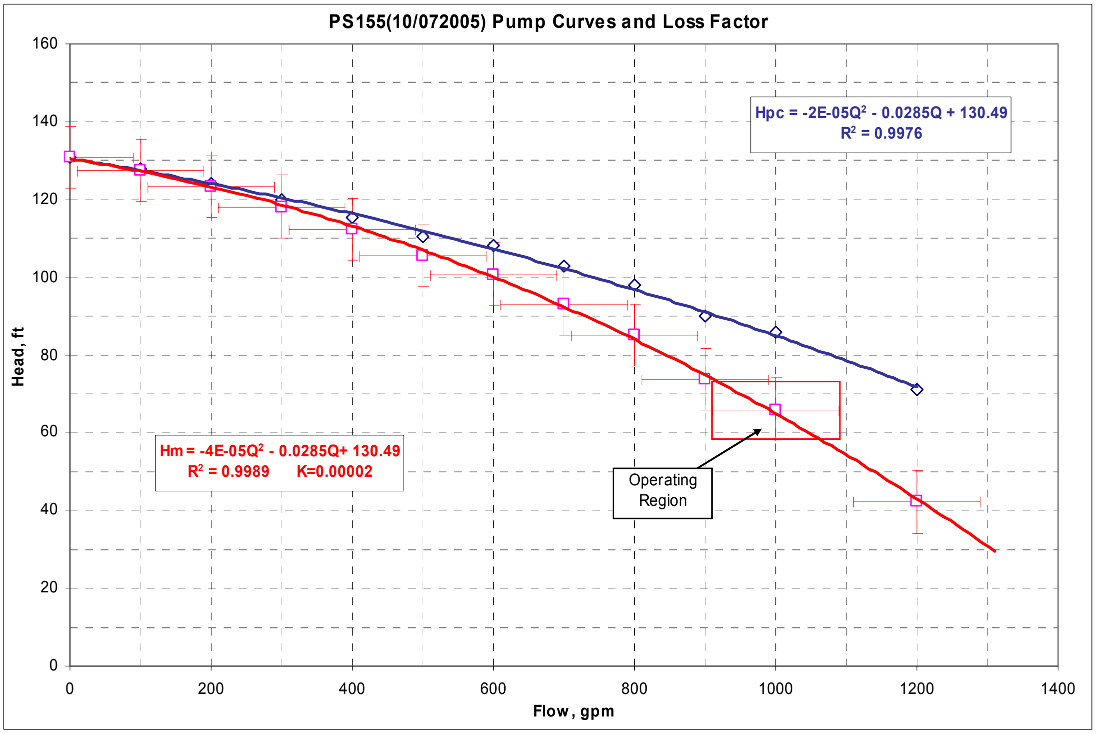


Fig 11. Nominal and modified pump curves. Error bars show the standard deviation of the mean for a 95% of confidence level. Shaded rectangle locates the operating region of the pump. Upper curve: Manufacturer's pump curve (H_{pc}). Lower curve: Modified pump curve (H_m)

3.2 Handling and forecasting of wet weather I/I conditions

SCADA monitoring, together with other information systems, like adequately located rain gauge networks, can be useful tools in the assessment and forecasting of wastewater storage and flow conditions through our basin networks due to the critical significance of the determination of possible overloads of the system during wet weather or extreme rain events. A tentative preliminary study of the correlation between wet weather events and basin overload conditions was attempted for PS 155 in order to assess the impact of rain events over the inflow conditions of this particular basin. Three rain events, corresponding to the 5th, 10th and 20th of June 2005 were considered in order to have minimum preliminary comparative sets of data.

Preliminary results showed an apparent strong linear correlation between the cumulative rate of rainfall and the behavior of the volumes of flow entering a given basin. Figures 12 to14 below show some of these results.

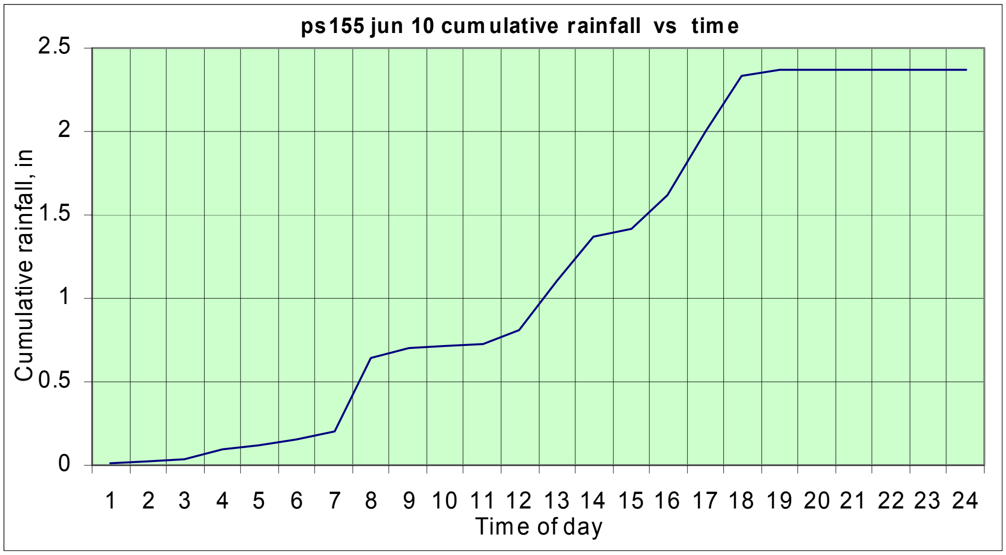


Fig. 12. PS 155 cumulative rainfall versus time. June 10 rain event.

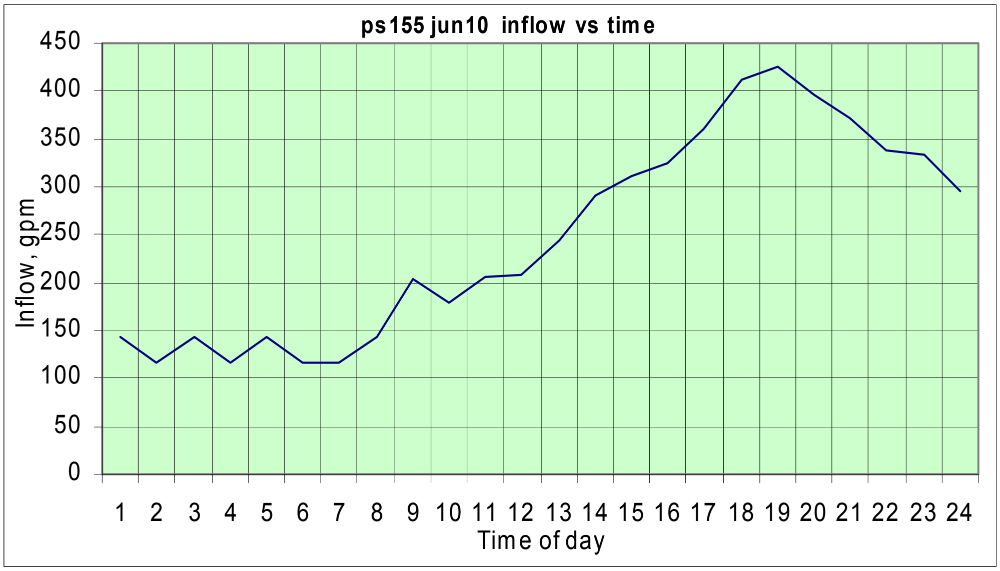


Fig.13. PS 155 influent flow(hydrograph versus time. June 10 rain event.

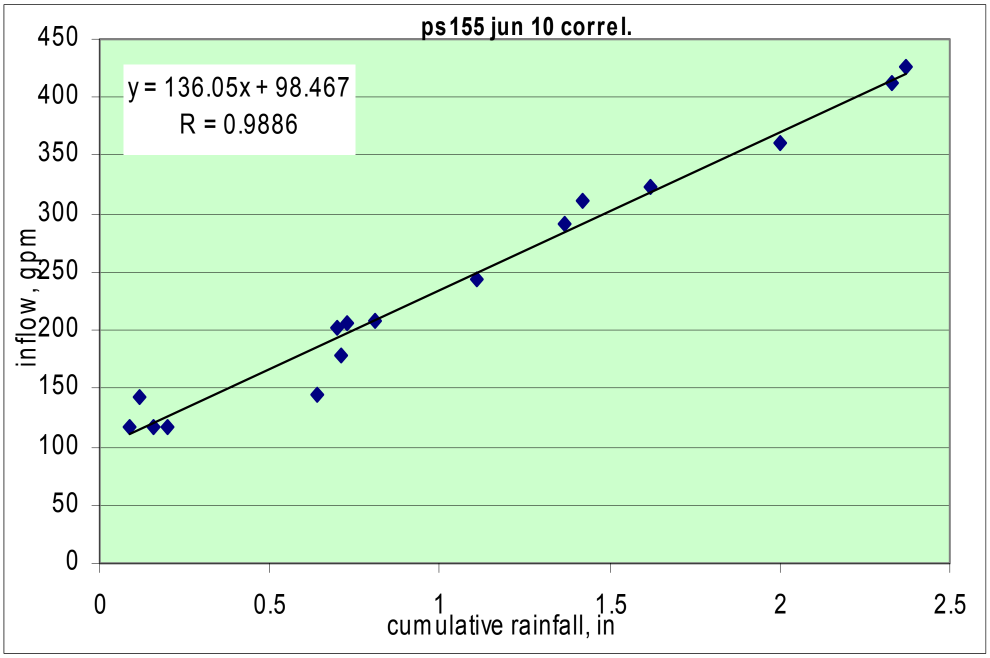


Fig.14. PS 155 Inflow/Rainfall correlation. June 10 rain event.

Linear correlation coefficients were obtained showing how the influent flows vary with the accumulation of rainfall. According to these preliminary results, for each inch of rainfall accumulated over this basin area , there is an increase of influent flow within a range from 140 to 200 gpm. Due to the fact that the physical conditions of the network that allow infiltration/inflow streams to enter the system are approximately constant for that basin, these figures should not vary dramatically with time for a given basin configuration. These results could allow us to forecast with certainty the approximate amounts of water that will be entering a certain pump station basin given the number of inches of rainfall predicted for that location. Further studies are necessary for the confirmation and of these results.

3.3 Summary, Conclusions and Recommendations

1. Results of the series of testing performed on stations 155, 183 and 196 are shown in figures 15 through 17, and in Table 4 below. In general, for stations 183 and 196 there are apparent reductions of the average daily volume of sewage processed that could be as high as one quarter of the total volume collected through the basin. This reduction, however, is not apparent for PS 155. Statistical dispersions of the data processed for this pump station suggest that further testing series should be performed to fine tune these results. With the application of this method of storage optimization to our entire network, significant quantities of infiltration/inflow water can be prevented from entering our sanitary sewer collection and treatment facilities.

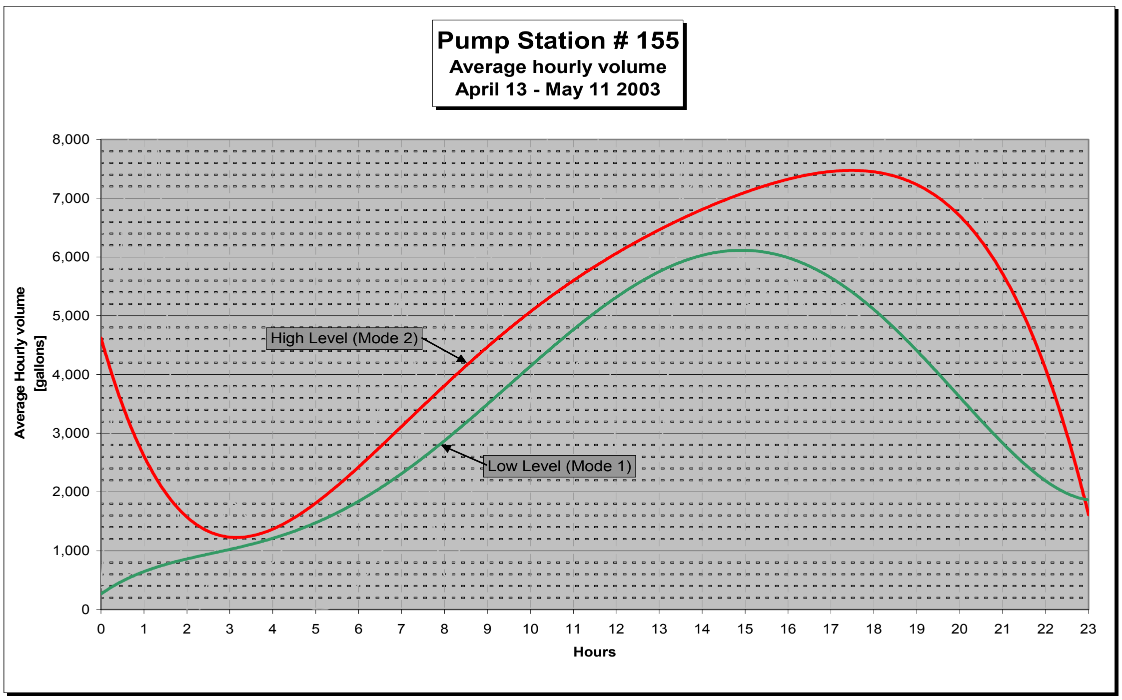


Fig. 15. Average Hourly volume of sewage collected under both modes for PS 155.

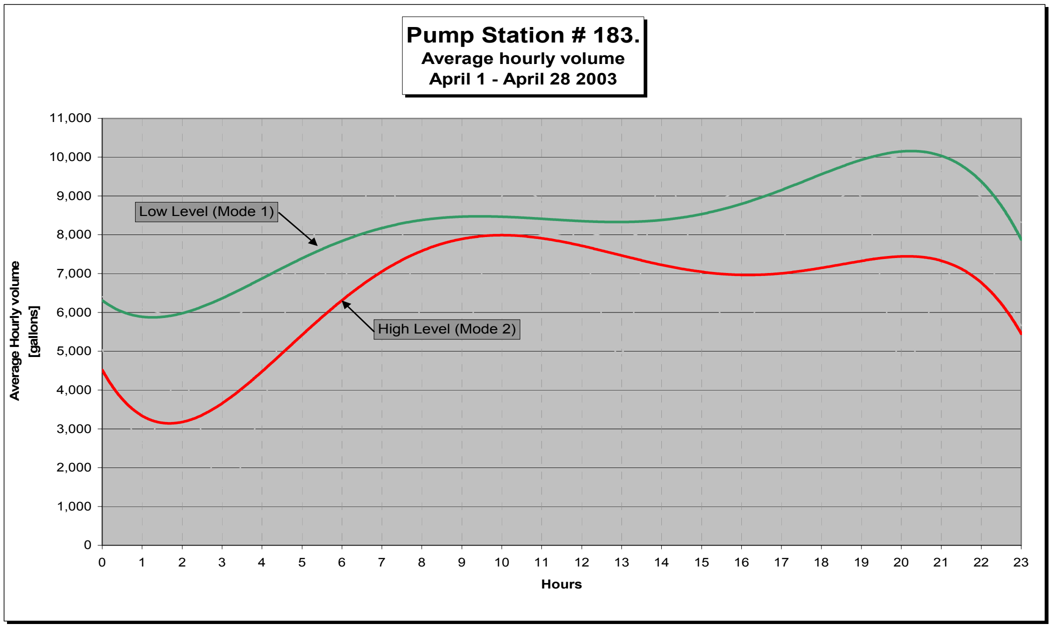


Fig. 16. Average Hourly volume of sewage collected under both modes for PS 183.

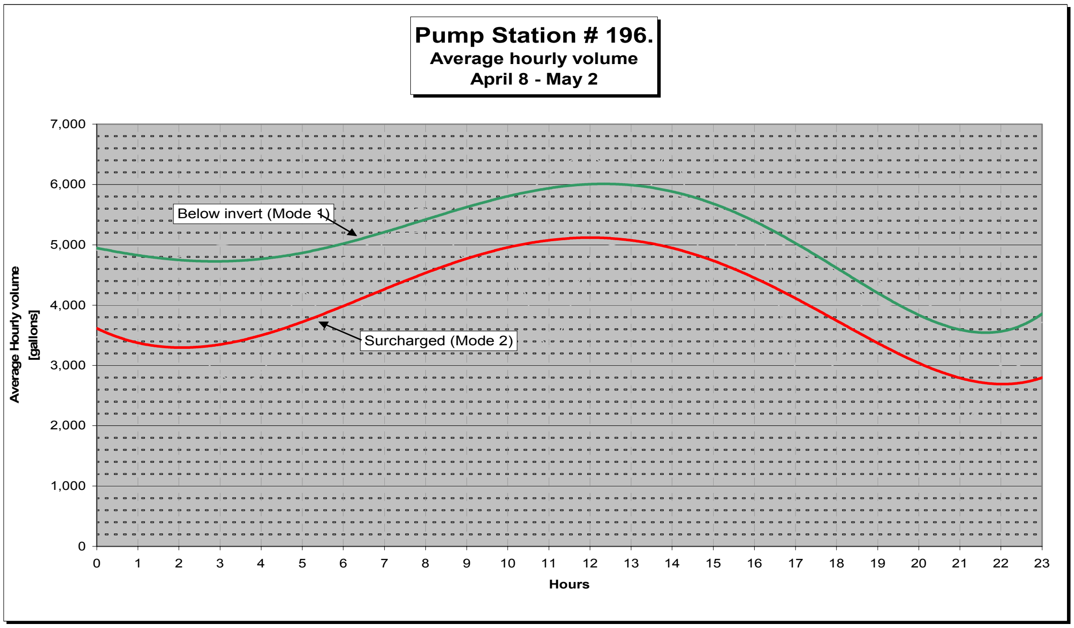


Fig. 17. Average Hourly volume of sewage collected under both modes for PS 196.

Pump Station	Average Daily Volume of sewage collected, gal		Volume Reduction, gal	Percent Reduction %
	Mode			
	Below Invert	Surcharged		
155	91198	95540	-4342	-5
183	205999	154258	51741	25
196	119558	95327	24231	20

Table 4. Results of average sewage volumes collected under both modes.

2. A great amount of information on the behavior of the flow regimes in our sanitary sewer network has been collected that allows us to study, monitor, and control and improve the different aspects of our System Storage Optimization Pilot Program in a much more realistic way since the implementation of this program in 1999. The modeling of target processes can be now performed in a much more accurate and precise fashion, and past experimental work represents a strong foundation on which the future researching and testing activities will be based. New collected data does not disprove, but instead reinforces and enriches those preliminary tests done since the beginning of the SSOPP.
3. Installation of additional groundwater monitoring well sample locations were initiated last year and will allow monitoring the behavior of the water table around groups of stations selected for the Pilot Program.
4. A series of upgrades for the SCADA RTU pump station program, as well as some miscellaneous improvements have been implemented since 1999.
5. Additional SCADA monitoring display additions and modifications have been achieved during the past year that includes not only the original first three stations(155, 183, and 196) but also the additional 15 pump stations considered for the continuation of program
6. Modified pump curves have been modeled taking into account the statistical conditions, as well as the values for K loss factors. Although manufacturer pump curves could be of second or third degree, modified curves have been approximated to a second degree, within the working range considered. Calculated K factors have been obtained using arbitrarily selected pump cycles, so the fact that a pump station is actually the combination of two pumps working alternately has to be considered. Therefore, K factors can be calculated as “equivalent pump station K factors”, which can be considered constant for each pump station.
7. Updated pump flow, head and K values have been incorporated to SCADA RTU signal settings for pump stations 155, 183, 196, allowing more realistic values for the signals involved. These values, however, have to be fine-tuned in subsequent steps to improve flow computations.
8. Estimation of pumping rates using the calculated modified head curves, when applied to surcharge conditions (from previously done tests, 2003), agree with the predicted pumping rates.
9. RTU raw data could be modified using the same program to avoid boundary transient values that affect the correct processing of data. Application of constraint conditions in convenient steps of the algorithm, as well as some specific statistical smoothing of processed data will increase the continuity and reliability of displayed SCADA graphs.

10. Calculation of modified curves and K factors under surcharged conditions are recommended, although some preliminary results show small changes in the results, with respect to below-invert conditions.
11. Program algorithms could be improved to include calculations during surcharge conditions to reflect actual values of the incoming flow, taking in account specific basin configuration in each case.
12. The wet weather I/I calibration of the first 18 pump stations considered for this Program should be implemented for the proper handling and forecasting of the high volumes of flows expected to fall and enter the sewer system during important rain events, mainly by the wet seasons to come.

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